2007 Annual Report of Winter Chinook Propagation Activities

A U.S. Fish & Wildlife Service Report

U.S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
Red Bluff, California 96080
August 2008

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INTRODUCTION

Due to severe declines in adult returns, the National Marine Fisheries Service listed Sacramento River winter Chinook salmon as threatened under the emergency listing procedures for the Endangered Species Act (16 U.S.C.R. 1531-1543) on August 4, 1989 (54 Federal Register 32085). Winter Chinook were formally added to the list of federally threatened species by final rule on November 5, 1990 (55 Federal Register 46515). Despite early efforts to restore the population, adult returns of winter Chinook continued to decline. In January 1994, the National Marine Fisheries Service reclassified winter Chinook salmon as endangered.

To supplement natural production and reduce the risk of extinction, the U.S. Fish and Wildlife Service (Service) developed an artificial propagation program for winter Chinook salmon in 1989. The winter Chinook propagation program was initially located at Coleman National Fish Hatchery (NFH) on Battle Creek, a tributary of the Sacramento River. However, fish reared at Coleman NFH tended to return to Battle Creek rather than the desired location of the Sacramento River. To alleviate this problem, a new hatchery facility, Livingston Stone NFH, was established in 1998 along the Sacramento River at the base of Shasta Dam. Two thousand seven marks the nineteenth year of the winter Chinook propagation program and the tenth year the program has been conducted at the Livingston Stone NFH.

METHODS

Brood stock

Collection

Prior to collecting winter Chinook brood stock in 2007, the Service developed a brood stock collection plan that established an annual collection goal and set forth monthly collection targets spread throughout the run. Brood stock collection guidelines for winter Chinook allow the Service to capture up to 15% of the run size. A run size of 800 or greater allows for a maximum of 120 fish to be retained as brood stock. In 2007, the pre-season run estimate was greater than 800; therefore, the Service established an annual collection goal of up to120 adult winter Chinook salmon. The timing of brood stock collection was scheduled to mimic the historic migration timing past the Red Bluff Diversion Dam. Monthly collection targets were established, as follows: 1.8% (2 fish) in December, 5.1% (6 fish) in January, 9.6% (12 fish) in February, 36.0% (43 fish) in March, 28.6% (34 fish) in April, 8.9% (11 fish) in May, 6.8% (8 fish) in June, and 3.4% (4 fish) in July. Deviation from the brood stock collection plan occurs when monthly collection targets are not fulfilled. When this occurs, the Service may increase collection targets for subsequent months so that the annual collection goal for the winter Chinook propagation program is maintained. The Keswick Dam fish trap was the only trap used to collect winter Chinook brood stock in 2007. The alternate trap located at the Red Bluff Diversion Dam was operated in 2007, however, no winter Chinook were collected at that location.

Handling and Transportation

Fishes collected at the Keswick Dam fish trap were crowded into a 1,000 gallon brail-lift, from which they were transferred directly into an aerated and insulated 1,200 or 1,600-gallon transport tank and driven to Livingston Stone NFH. At Livingston Stone NFH the fish were anaesthetized with CO_2 to facilitate handling. A preliminary run assignment was made (i.e., winter-run or non-winter-run) based on phenotypic characteristics (e.g., color, degree of ripeness, fish size, amount of fungus, and collection date). All fish receive a floy tag below the dorsal fin and a small piece of fin tissue is taken for genetic analysis. Fish classified as non-winter-run were either transported back to the Sacramento River and released or, alternatively, transported to Coleman NFH for use brood stock in the late-fall Chinook propagation program. Fish classified as phenotypic winter-run were quarantined in a 20-foot circular tank pending genetic confirmation of their run type. Fish genetically confirmed as winter-run were transferred into a separate 20-foot circular adult holding tank until spawned. Those genetically identified as non-winter-run were returned to the Sacramento River.

Run Identification

A genetic-based run assignment was used to classify fish as either winter-run or non-winter-run Chinook (University of California, Davis - Bodega Marine Laboratory 2001). Analyses were conducted at the Service's Abernathy Fish Technology Center. Tissue samples were analyzed at a suite of microsatellite markers selected for their diagnostic power in distinguishing winter Chinook from other Chinook salmon populations (University of California – Davis Bodega Marine Laboratory 2001). Following the methods described by Banks et al. (1999) and Greig and Banks (1999), extracted DNA from samples was amplified by polymerase chain reaction, analyzed, and overall genotypes converted to GENEPOP format. Duplicate samples were run to confirm genotypes. A log-of-the-odds (LOD) score was generated using the computer software WHICHRUN (Banks and Eichert 2000) and used to assign individual Chinook as either winter-run or non-winter-run. A LOD score of two or greater, based on seven loci, was used to determine which fish would be retained as brood stock. Run-assignments for individual fish were transmitted back to Livingston Stone NFH, usually within 72 hours of receipt of the tissue sample at the Abernathy Fish Technology Center.

Health

Various therapeutic and prophylactic treatments were used on winter Chinook salmon brood stock to increase survival of adults and reduce risks of disease transmission to offspring (Table 1). Additionally, effects of stress on brood stock were reduced with salt, Poly Aqua, and anesthetics. Hatchery personnel and staff from the California-Nevada Fish Health Center closely monitored fish health. Brood stock were treated with malachite green to prevent fungal infections and erythromycin injections (target dosage of 20 mg/kg) were used to prevent transmission of *Renibacterium salmoninarum* to the progeny. No chemical treatments were administered to fish while held in quarantine and fish returned to the river were not subjected to

chemical treatments. California-Nevada Fish Health Center personnel tested for the presence of pathogens in the brood stock.

Table 1. Drugs and treatments that may be applied to maintain the health of winter Chinook salmon held at Livingston Stone National Fish Hatchery.

Drug/Treatment	Dosage	Administered by	Use
Erythromycin	20 mg/kg	dorsal sinus injection	antibacterial
Iodophor	75 ppm	bath	antibacterial
Liquamycin	20 mg/kg	Intraperitoneal injection	antibacterial
Malachite green	1 ppm	bath	antifungal
Formalin	167 ppm	flow through	antifungal
MS-222		bath	anesthetic
Poly Aqua	1 qt/1,200 gallons	bath/flow through	stress reducer
Salt		bath/flow through	stress reducer
Chloramine-T	15 ppm	bath	antibacterial

Spawning

Winter Chinook brood stock were examined twice weekly to assess their state of sexual maturity. Fish were crowded into a pie-shaped containment area using a hinged crowder consisting of two solid vinyl-covered screens. Tricane methanesulfonate (MS-222) was added to anaesthetize the fish so they could be examined for maturity and overall fish health.

Luteinizing Hormone-Releasing Hormone analogue (LH-RH_a) implants were administered to accelerate final gamete maturation in fish that had already undergone gametogenesis and to synchronize maturation of brood stock (Tables 2 and 3). The LH-RH_a implants release 30% of their content in the first three days after injection and the remaining hormone over a 20-day period to sustain an effective concentration within the fish. The implant dosage was 150 or 250 µg (supplied by Syndel International Inc.). Implants were injected into the dorsal muscle lateral and anterior to the dorsal fin with the use of a Ralgro pellet injector. Eighteen females and two males received LH-RH_a injections.

When a female salmon was identified as being sexually mature, it was euthanized, removed from the tank, and rinsed in fresh water to remove any remaining MS-222. Each female was assigned a number and each male was assigned a letter. The caudal artery of the female was severed so that blood would not mix into the eggs. Eggs were removed by making an incision from the vent to the pectoral fin and separated into two approximately equal groups. Each group was fertilized with semen from a different male, forming two half-sibling family groups. For example, when female 1 was spawned with males A and B, “family groups” 1A and 1B were created. After mixing semen and eggs, tris-glycine buffer was added to extend sperm life and motility. Spawned males were either returned to the holding tank for additional spawning or euthanized. Males were spawned a maximum of four times. When possible, each fish captured from the Sacramento River was spawned with at least two others.

Table 2. Spawning and drug treatment history of individual female Chinook salmon held at Livingston Stone National Fish Hatchery, 2007.

Tag	Date	Fork		Date	Date	Days in	Erythromycin		Liquamycin		LH-RHa		No. of Malachite
		Length	Weight				Dose		Dose		Dose		Green
Number	Captured	(mm)	(lb)	Spawned	Died	Captivity	(ml)	Injections	(ml)	Injections	(ml)	Injections	Treatments
Y-251	3/13/2007	750	12.70	PSM	4/6/2007	23	n/a	none	0.80	1	n/a	none	8
Y-252	3/13/2007	760	13.24	PSM	4/17/2007	34	n/a	none	n/a	none	n/a	none	11
Y-420	4/10/2007	820	16.00	PSM	5/7/2007	26	n/a	none	0.80	1	250	1	7
Y-333	3/27/2007	790	13.50	5/29/2007	5/29/2007	62	0.65	2	n/a	none	250	1	18
Y-340	3/27/2007	850	17.70	5/31/2007	5/31/2007	64	0.75	2	n/a	none	250	1	19
Y-253	3/13/2007	790	13.60	6/4/2007	6/4/2007	82	0.65	1	n/a	none	n/a	none	25
Y-284	3/20/2007	770	14.00	6/4/2007	6/4/2007	75	0.65	2	n/a	none	250	1	23
Y-425	4/10/2007	920	21.90	6/7/2007	6/7/2007	57	1.05	2	n/a	none	250	1	16
Y-439	4/17/2007	690	8.60	6/14/2007	6/14/2007	57	0.40	2	n/a	none	250	1	16
Y-349	3/27/2007	775	12.80	6/14/2007	6/14/2007	78	0.65	2	0.65	2	250	1	23
Y-283	3/20/2007	810	14.25	6/14/2007	6/14/2007	85	0.65	2	n/a	none	250	1	26
Y-294	3/20/2007	770	12.00	6/18/2007	6/18/2007	89	0.65	2	n/a	none	n/a	none	27
Y-273	3/20/2007	750	10.70	6/21/2007	6/21/2007	92	0.50	2	n/a	none	n/a	none	28
OR-013	6/11/2007	865	16.90	6/21/2007	6/21/2007	9	n/a	none	n/a	none	250	2	2
OR-010	6/11/2007	770	11.64	6/21/2007	6/21/2007	9	n/a	none	n/a	none	250	2	2
OR-019	6/19/2007	778	12.80	6/21/2007	6/21/2007	1	n/a	none	n/a	none	n/a	none	0
OR-016	6/19/2007	794	12.78	6/21/2007	6/21/2007	1	n/a	none	n/a	none	n/a	none	0
Y-272	3/20/2007	760	11.60	6/28/2007	6/28/2007	99	0.50	2	n/a	none	n/a	none	30
Y-312	3/27/2007	740	10.60	7/2/2007	7/2/2007	96	0.50	2	n/a	none	250	1	28
Y-468	5/1/2007	780	14.90	7/2/2007	7/2/2007	61	0.75	1	n/a	none	250	1	17
Y-317	3/27/2007	790	13.06	7/2/2007	7/2/2007	96	0.65	2	n/a	none	250	1	28
OR-023	6/26/2007	680	7.70	7/2/2007	7/2/2007	5	n/a	none	n/a	none	n/a	none	1
Y-322	3/27/2007	710	9.80	7/9/2007	7/9/2007	103	0.50	2	n/a	none	n/a	none	30
OR-061	7/17/2007	780	11.50	7/17/2007	7/17/2007	0	n/a	none	n/a	none	n/a	none	0
Y-291	3/20/2007	720	8.60	7/19/2007	7/19/2007	120	0.40	2	n/a	none	250	1	36
OR-051	7/17/2007	800	13.60	7/19/2007	7/19/2007	1	n/a	none	n/a	none	n/a	none	0
OR-054	7/24/2007	700	8.62	7/26/2007	7/26/2007	1	n/a	none	n/a	none	n/a	none	0

Table 3. Spawning and drug treatment history of individual male Chinook salmon held at Livingston Stone National Fish Hatchery, 2007.

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Liquamycin Dose (ml)	Liquamycin Injections	LH-RHa Dose (ml)	LH-RHa Tag Number	No. of Malachite Green Treatments
Y-290	3/20/2006	900	20.15	PSM	4/5/2006	15	n/a	none	n/a	none	6
Y-339	3/27/2006	880	19.7	PSM	5/17/2006	50	n/a	none	n/a	none	14
Y-447	4/17/2006	805	14.8	PSM	6/26/2006	69	n/a	none	n/a	none	20
Y-403	4/10/2007	950	17.4	5/29/2007 5/31/2007	6/5/2007	55	n/a	none	250	2	15
Y-223	3/13/2007	840	17.2	5/29/2007 5/31/2007	6/7/2007	85	n/a	none	250	1	26
Y-421	4/10/2007	860	17.5	6/4/2007 6/4/2007	6/5/2007	55	n/a	none	n/a	none	15
Y-410	4/10/2007	1000	30	6/4/2007 6/14/2007 6/14/2007	6/21/2007	71	n/a	none	n/a	none	20
Y-278	3/20/2007	740	10.6	6/4/2007 6/7/2007 6/14/2007	6/18/2007	89	0.5	2	n/a	none	27
Y-378	3/27/2007	830	12.9	6/7/2008	6/10/2007	74	n/a	none	n/a	none	22
Y-375	3/27/2007	860	16.3	6/14/2007 6/21/2007 6/21/2007	6/25/2007	89	n/a	none	n/a	none	26
Y-395	4/10/2007	920	20	6/14/2007 6/18/2007 7/2/2007	7/5/2007	85	n/a	none	n/a	none	24
Y-336	3/27/2007	840	16.6	6/14/2007 6/18/2007	7/13/2007	107	n/a	none	n/a	none	32
Y-422	4/10/2007	860	19.3	7/2/2007 6/21/2007 6/28/2007 7/2/2007	7/9/2007	89	n/a	none	n/a	none	25
Y-341	3/27/2007	820	14	6/12/2007 6/28/2007 7/2/2007	7/9/2007	103	n/a	none	n/a	none	30

Table 3. (continued)

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Liquamycin Dose (ml)	Liquamycin Injections	LH-RHa Dose (ml)	LH-RHa Injections	No. of Malachite Green Treatments
OR-017	6/19/2007	950	22.1	6/21/2007	6/21/2007	1	n/a	none	n/a	none	0
OR-018	6/19/2007	890	16.94	6/21/2007 6/21/2007	6/21/2007	1	n/a	none	n/a	none	0
OR-015	6/19/2007	820	13.76	6/21/2007 6/21/2007	6/21/2007	1	n/a	none	n/a	none	0
Y-332	3/27/2007	720	9.6	7/2/2007 7/17/2007 7/19/2007 7/19/2000	7/26/2007	120	n/a	none	n/a	none	33
Y-387	4/3/2007	770	11.42	7/2/2007 7/2/2007 7/17/2007	7/19/2007	106	n/a	none	n/a	none	30
Y-330	3/27/2007	830	15.4	7/9/2007 7/19/2007 7/19/2007	7/29/2007	123	n/a	none	n/a	none	35
Y-390	4/3/2007	820	13.04	7/2/2007 7/9/2007	7/13/2007	100	n/a	none	n/a	none	29
OR-063	7/24/2007	530	3.58	7/26/2007	7/31/2007	6	n/a	none	n/a	none	1
OR-062	7/24/2007	800	11.4	7/26/2007	7/26/2007	1	n/a	none	n/a	none	0

Progeny

Eggs and Juvenile Rearing

After fertilization, winter Chinook eggs were placed in Heath incubator trays and disinfected with a 75 parts per million (ppm) iodophor bath for 15 minutes. Incubating eggs were treated twice a week with a 15 minute flow-through treatment of 1,400 ppm formalin to prevent excessive fungus. Initial water flow in the incubator trays was four gallons per minute (gpm) and later increased to six gpm at eye-up. After eye-up, eggs were shocked and non-viable eggs were removed. Formalin treatments were discontinued once eggs had hatched. Sac fry were left in the incubator trays until button-up, at which time they were transferred to 30-inch diameter (10.2 cubic foot) circular tanks and started on commercial feed.

Juveniles were initially fed Nelson and Sons Silvercup Soft Moist Starter. *Artemia nauplii* (Cyclop-eeze™ from Argent Chemical Laboratories) were added to increase interest in the feed. The fish were subsequently fed Nelson and Sons Soft Moist Starter #1. Once they attained a size of approximately 300 to-the-pound, they were fed Nelson and Sons Soft Moist Starter #2 until release. Feeding rates were determined using Silvercup's feeding guidelines, which indicate the appropriate feed ration based on average monthly water temperature. Due to tank space limitations at Livingston Stone NFH, family groups were combined as fish size increased.

Health

To maintain sanitary rearing environments, rearing units were cleaned daily. Juvenile winter Chinook were tested for the presence of pathogens by California-Nevada Fish Health Center personnel.

Marking and Tagging

All winter Chinook juveniles were coded-wire tagged between December 27, 2007 and January 9, 2008. A total of 46 family groups were produced (38 natural-origin by natural-origin and 8 hatchery-origin by natural-origin). The natural-origin by natural-origin family groups were combined into seven unique groups with each receiving a separate tag code (Table 4). The hatchery-origin by natural-origin family groups were combined into two unique groups with each receiving a separate tag code.

Table 4. Brood year 2007 winter Chinook salmon release length (mm) and number by coded-wire tag (CWT) code, family group, and parental origin.

CWT Code	Family Group	Parental Origin	Number Tagged	Tagging Mortalities	Proportion Tags Retained	Tagged Fish Released	Number Released	Fork Length (mm)		
								Avg.	Min.	Max.
054553	8E, 9H, 9I, 10J, 10K	N x N	7,479	1	0.97	7,229	7,478	92.54	83	109
054554	13M, 13N, 14M	H x N	7,386	0	0.96	7,103	7,386	90.08	76	105
054604	15K, 16H, 16K, 17I, 17J	N x N	7,437	0	0.93	6,935	7,437	88.04	72	99
054605	12G, 12L, 18P, 18R	N x N	6,912	15	0.96	6,604	6,897	83.15	63	102
054606	14N, 19O, 19P, 24S, 24T	H x N	8,229	10	0.97	7,945	8,219	82.47	65	105
054607	20Q, 20R, 21O, 21P, 22O, 22Q, 23O, 23Q	N x N	8,487	8	0.98	8,309	8,479	82.02	47	101
054608	1A, 1B, 2A, 2B, 15J	N x N	8,819	8	0.95	8,370	8,811	87.82	58	110
054609	3C, 3D, 4C, 4E, 5E, 5F	N x N	9,384	2	0.98	9,194	9,382	91.05	82	118
054610	6H, 6G, 7D, 7I, 8D	N x N	7,812	18	0.95	7,430	7,794	94.01	78	115
		Total	71,945	62		69,120	71,883			

Assessment of Potential Genetic Impacts

Prior to and following the release of juvenile winter Chinook into the Sacramento River, the Service estimated the "effective population size" of the winter Chinook salmon population, both with and without the influence of hatchery-origin fish. The effective population size estimate (N_e) measures the rate of genetic drift within a population and provides an assessment of risk of inbreeding resulting from the release of the juveniles from the hatchery propagation program. The N_e is directly related to the rate of loss of genetic diversity and the rate of increase in inbreeding within a population (Riemann and Allendorf 2001), and is an important concept in managing conservation programs for threatened or endangered salmonid populations, including Sacramento River winter Chinook. In most cases N_e is expected to be smaller than the actual number of adults in a spawning population.

The estimation of N_e was based on the estimated total run size of winter Chinook salmon to the Sacramento River in 2007. Two estimates of N_e were calculated: one assuming genetic contribution by 10% of the run size estimate (Bartley et al., 1992) and one assuming genetic contribution by 33% of the run size estimate (Robin Waples, NMFS, Northwest Fisheries Center, Seattle, WA, personal communication). The Service's estimate of effective population size was sent to NOAA Fisheries and the California Department of Fish and Game for review and approval prior to releasing juvenile winter Chinook.

RESULTS

Brood stock

Collection and Disposition

The first winter Chinook was captured on January 23rd and the last was captured on July 24th (Table 5, Figure 1). Brood stock collection was slow early in the collection year due to high river flows preventing the Keswick Dam trap from being run. Most of the brood year 2007 winter Chinook were collected from late-March through April (Table 5, Figure 1). The pattern of collection for non-winter Chinook was similar to that of winter Chinook (Table 5, Figure 1). A total of 285 Chinook salmon were captured at the Keswick Dam trap (Table 6). Of those, 55% (n = 157) were identified as winter-run based on genetic data or phenotypic characteristics. Females comprised 48% (n = 75) of the winter Chinook salmon captured, males comprised 51% (n = 80). Hatchery-origin fish comprised 55% (n = 86) of the winter Chinook captured and 38% (n = 107) of all Chinook captured.

Ninety-nine winter-run Chinook, 36 non-winter-run Chinook, and 4 Chinook of undetermined run were collected and released without being quarantined (Table 6). Five Chinook were held in quarantine and later released back into the Sacramento River; four of these fish were winter-run and one was a non-winter-run (Table 6). Quarantined fish were held for no more than two days. Fifty-three winter Chinook salmon were retained for brood stock. Among these, 44 were spawned and 9 died before they could be spawned. Seventy non-winter Chinook were

transferred to Coleman NFH for use as late-fall Chinook salmon brood stock and fifteen non-winter Chinook were euthanized.

Because the winter Chinook brood stock collected at the Keswick Dam fish trap were insufficient to meet the Service's annual collection goal, the Service initiated brood stock collection at the alternate trapping facility, the Red Bluff Diversion Dam (RBDD). Five Chinook from the RBDD were phenotypically identified as winter Chinook and transferred to Livingston Stone NFH and quarantined until a genetic run determination was made. All five fish were genetically identified as being non-winter Chinook. These fish were then transferred to the boat ramp at Bend Bridge and released:

Table 5. Brood year 2007 Chinook salmon captured and tissue sampled for genetic run assignment and their final disposition. Fish with the adipose fin present were natural-origin, fish with the adipose fin absent were hatchery-origin.

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
12/26/2006	80001	Y-093	Present	Male	930	Non-Winter	TransferredCNFH
12/26/2006	80002	Y-094	Present	Female	790	Non-Winter	TransferredCNFH
12/26/2006	80003	Y-095	Present	Female	870	Non-Winter	TransferredCNFH
12/26/2006	80004	Y-096	Present	Male	980	Non-Winter	TransferredCNFH
12/26/2006	80005	Y-097	Present	Male	1000	Non-Winter	Released@Caldwell
12/26/2006	80006	Y-099	Present	Male	850	Non-Winter	Released@Caldwell
12/26/2006	80007	Y-103	Present	Male	1030	Non-Winter	TransferredCNFH
1/3/2007	3022	Y-110	Present	Female	820	undetermined	TransferredCNFH
1/3/2007	3023	Y-112	Present	Male	1020	undetermined	TransferredCNFH
1/3/2007	3024	Y-107	Present	Female	930	undetermined	TransferredCNFH
1/3/2007	3025	Y-115	Present	Female	950	undetermined	TransferredCNFH
1/3/2007	3026	Y-121	Present	Female	900	undetermined	TransferredCNFH
1/3/2007	3027	Y-106	Present	Female	880	undetermined	TransferredCNFH
1/3/2007	3028	Y-120	Present	Female	840	undetermined	TransferredCNFH
1/3/2007	3029	Y-117	Present	Male	1070	undetermined	TransferredCNFH
1/3/2007	3030	Y-113	Present	Male	980	undetermined	TransferredCNFH
1/3/2007	3032	Y-114	Present	Male	1030	undetermined	TransferredCNFH
1/3/2007	3033	Y-109	Present	Male	940	undetermined	TransferredCNFH
1/3/2007	80008	Y-104	Present	Female	880	Non-Winter	Released@Posse
1/3/2007	80009	Y-118	Present	Female	1000	Non-Winter	Released@Posse
1/3/2007	80010	Y-122	Present	Female	740	Non-Winter	Released@Posse
1/3/2007	82001	Y-108	Present	Female	880	undetermined	TransferredCNFH
1/3/2007	82002	Y-111	Present	Male	670	undetermined	TransferredCNFH
1/3/2007	82003	Y-116	Present	Female	800	undetermined	TransferredCNFH
1/23/2007	80011	Y-125	Absent	Unknown	720	Winter	Released@Posse
1/23/2007	80012	Y-127	Present	Female	1000	Non-Winter	Released@Posse
1/23/2007	80013	Y-134	Absent	Male	970	Non-Winter	Sacrificed
1/23/2007	80014	Y-140	Absent	Female	860	Non-Winter	Sacrificed
1/23/2007	80015	Y-141	Absent	Male	930	Non-Winter	Sacrificed
1/23/2007	82004	Y-129	Present	Female	850	undetermined	DIP
1/23/2007	82005	Y-137	Present	Female	890	undetermined	TransferredCNFH
1/23/2007	82006	Y-124	Present	Female	930	undetermined	TransferredCNFH
1/23/2007	82007	Y-139	Present	Male	940	undetermined	TransferredCNFH
1/23/2007	82008	Y-132	Present	Male	980	undetermined	TransferredCNFH
1/23/2007	82009	Y-133	Present	Male	1020	undetermined	TransferredCNFH
1/23/2007	82010	Y-138	Present	Male	980	undetermined	TransferredCNFH
1/23/2007	82011	Y-130	Present	Female	810	undetermined	TransferredCNFH
1/23/2007	82012	Y-131	Present	Female	930	undetermined	TransferredCNFH

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
1/23/2007	82013	Y-136	Present	Female	950	undetermined	TransferredCNFH
1/23/2007	82014	Y-135	Present	Female	970	undetermined	TransferredCNFH
1/30/2007	80016	Y-144	Absent	Unknown	790	Winter	Released@Posse
1/30/2007	80017	Y-147	Present	Male	1000	Non-Winter	Released@Posse
1/30/2007	80018	Y-152	Absent	Male	770	Winter	Released@Posse
1/30/2007	80019	Y-161	Absent	Male	760	Winter	Released@Posse
1/30/2007	80020	Y-170	Absent	Female	890	Winter	Released@Posse
1/30/2007	80021	Y-174	Present	Female	940	Non-Winter	Released@Posse
1/30/2007	80022	Y-177	Absent	Male	980	Non-Winter	Sacrificed
1/30/2007	80023	Y-176	Absent	Female	810	Non-Winter	Sacrificed
1/30/2007	82015		Present	Male	1030	undetermined	TransferredCNFH
1/30/2007	82016	Y-159	Present	Male	1045	undetermined	TransferredCNFH
1/30/2007	82017	Y-169	Present	Male	780	undetermined	TransferredCNFH
1/30/2007	82018	Y-155	Present	Female	950	undetermined	TransferredCNFH
1/30/2007	82019	Y-151	Present	Female	830	undetermined	TransferredCNFH
1/30/2007	82020	Y-158	Present	Female	910	undetermined	TransferredCNFH
1/30/2007	82021	Y-172	Present	Female	960	undetermined	TransferredCNFH
1/30/2007	82022	Y-163	Present	Male	920	undetermined	TransferredCNFH
1/30/2007	82023	Y-173	Present	Female	970	undetermined	TransferredCNFH
1/30/2007	82024	Y-156	Present	Female	920	undetermined	TransferredCNFH
1/30/2007	82025	Y-160	Present	Female	980	undetermined	TransferredCNFH
1/30/2007	82026	Y-166	Present	Male	1100	undetermined	TransferredCNFH
1/30/2007	82027	Y-154	Present	Male	1020	undetermined	TransferredCNFH
1/30/2007	82028	Y-168	Present	Male	1080	undetermined	TransferredCNFH
1/30/2007	82029	Y-146	Present	Female	830	undetermined	TransferredCNFH
1/30/2007	82030	Y-164	Present	Female	910	undetermined	TransferredCNFH
1/30/2007	82031	Y-165	Present	Female	980	undetermined	TransferredCNFH
1/30/2007	82032	Y-167	Present	Female	980	undetermined	TransferredCNFH
1/30/2007	82033	Y-143	Present	Male	1010	undetermined	TransferredCNFH
1/30/2007	82034	Y-142	Present	Male	1020	undetermined	TransferredCNFH
1/30/2007	82035	Y-157	Present	Female	940	undetermined	TransferredCNFH
1/30/2007	82040	Y-149	Present	Female	880	undetermined	TransferredCNFH
2/6/2007	80024	Y-179	Absent	Female	820	Winter	Released@Posse
2/6/2007	80025	Y-184	Present	Male	990	Winter	Released@Posse
2/6/2007	80026	Y-186	Absent	Female	785	Winter	Released@Posse
2/6/2007	80027	Y-194	Absent	Male	780	Winter	Released@Posse
2/6/2007	80028	Y-196	Absent	Female	810	Winter	Released@Posse
2/6/2007	80029	Y-198	Absent	Female	960	Winter	Released@Posse
2/6/2007	80030	Y-191	Present	Female	805	Winter	Released@Posse
2/6/2007	80031	Y-201	Absent	Female	840	Non-Winter	Sacrificed

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
2/6/2007	80032	Y-202	Absent	Male	910	Non-Winter	Sacrificed
2/6/2007	82036	Y-182	Present	Male	985	undetermined	TransferredCNFH
2/6/2007	82037	Y-188	Present	Male	1070	undetermined	TransferredCNFH
2/6/2007	82038	Y-190	Present	Male	980	undetermined	TransferredCNFH
2/6/2007	82039	Y-181	Present	Female	880	undetermined	TransferredCNFH
2/6/2007	82041	Y-183	Present	Male	1060	undetermined	TransferredCNFH
2/6/2007	82042	Y-189	Present	Male	995	undetermined	TransferredCNFH
2/6/2007	82046	Y-178	Present	Female	895	undetermined	TransferredCNFH
2/6/2007		Y-192	Absent	Female	780	undetermined	Released@Posse
2/13/2007	80033	Y-230	Absent	Male	970	Non-Winter	DIP
2/13/2007	80034	Y-233	Present	Female	924	Non-Winter	Released@Posse
2/13/2007	80035	Y-238	Present	Female	940	Winter	Released@Posse
2/13/2007	80036	Y-242	Absent	Female	700	Winter	Released@Posse
2/13/2007	80037	Y-246	Present	Female	980	Non-Winter	Released@Posse
2/13/2007	80038	Y-203	Absent	Male	900	Non-Winter	Sacrificed
2/13/2007	80039	Y-204	Absent	Male	950	undetermined	Sacrificed
2/13/2007	80040	Y-205	Absent	Female	860	Non-Winter	Sacrificed
2/13/2007	80041	Y-206	Absent	Female	940	Non-Winter	Sacrificed
2/13/2007	82043	Y-232	Present	Male	1090	undetermined	TransferredCNFH
2/13/2007	82044	Y-240	Present	Female	890	undetermined	TransferredCNFH
2/13/2007	82045	Y-228	Present	Female	860	undetermined	TransferredCNFH
2/13/2007	82047	Y-229	Present	Female	1010	undetermined	TransferredCNFH
2/13/2007	82048	Y-241	Present	Female	965	undetermined	TransferredCNFH
2/13/2007	82049	Y-236	Present	Female	960	undetermined	TransferredCNFH
2/13/2007	82050	Y-245	Present	Male	1030	undetermined	TransferredCNFH
2/13/2007	82051	Y-235	Present	Male	1030	undetermined	TransferredCNFH
2/13/2007	82052	Y-237	Present	Male	1050	undetermined	TransferredCNFH
2/13/2007	82055	Y-244	Present	Female	850	undetermined	TransferredCNFH
2/13/2007		Y-226	Absent	Male	925	undetermined	Released@Posse
2/20/2007	82053	Y-207	Present	Female	860	undetermined	TransferredCNFH
2/20/2007	82054	Y-209	Present	Male	1020	undetermined	TransferredCNFH
3/6/2007	80042	Y-248	Present	Male	1000	Non-Winter	Released@Posse
3/6/2007	80043	Y-210	Absent	Male	0	Non-Winter	Sacrificed
3/6/2007	80044	Y-211	Present	Male	980	Non-Winter	Released@Posse
3/6/2007	80045	Y-213	Absent	Male	730	Winter	Released@Posse
3/6/2007	80046	Y-215	Present	Female	850	Non-Winter	Released@Posse
3/6/2007	80047	Y-217	Absent	Male	820	Winter	Released@Posse
3/6/2007	80048	Y-219	Absent	Female	800	Winter	Released@Posse
3/6/2007	80049	Y-221	Absent	Male	780	Winter	Released@Posse
3/13/2007	80050	Y-223	Present	Male	840	Winter	Spawned

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
3/13/2007	80051	Y-224	Present	Male	910	Non-Winter	Released@Posse
3/13/2007	80052	Y-251	Present	Female	750	Winter	Prespawn
3/13/2007	80053	Y-252	Present	Male	760	Winter	Prespawn
3/13/2007	80054	Y-253	Present	Male	790	Winter	Spawned
3/13/2007	80055	Y-254	Present	Female	740	Winter	Released@Posse
3/13/2007	80056	Y-256	Absent	Male	810	Winter	Released@Posse
3/13/2007	80057	Y-258	Absent	Male	710	Winter	Released@Posse
3/13/2007	80058	Y-260	Present	Female	950	Non-Winter	Released@Posse
3/13/2007	80059	Y-262	Present	Female	740	Winter	Released@Posse
3/13/2007	80060	Y-264	Present	Female	790	Winter	Released@Posse
3/20/2007	80061	Y-266	Absent	Male	910	Winter	Released@Posse
3/20/2007	80062	Y-267	Present	Male	720	Non-Winter	Released@Posse
3/20/2007	80063	Y-268	Absent	Female	850	Winter	Released@Posse
3/20/2007	80064	Y-270	Absent	Male	950	Winter	Released@Posse
3/20/2007	80065	Y-272	Present	Male	760	Winter	Spawned
3/20/2007	80066	Y-273	Present	Male	750	Winter	Spawned
3/20/2007	80067	Y-274	Absent	Female	870	Winter	Released@Posse
3/20/2007	80068	Y-276	Absent	Male	800	Winter	Released@Posse
3/20/2007	80069	Y-278	Present	Female	740	Winter	Spawned
3/20/2007	80070	Y-279	Present	Female	740	Non-Winter	Released@Posse
3/20/2007	80071	Y-281	Absent	Female	740	Winter	Released@Posse
3/20/2007	80072	Y-283	Present	Female	810	Winter	Spawned
3/20/2007	80073	Y-284	Present	Female	770	Winter	Spawned
3/20/2007	80074	Y-288	Absent	Male	720	Winter	Released@Posse
3/20/2007	80075	Y-290	Present	Male	900	Winter	Prespawn
3/20/2007	80076	Y-291	Present	Male	790	Winter	Spawned
3/20/2007	80077	Y-292	Present	Female	800	Winter	Released@Posse
3/20/2007	80078	Y-294	Present	Male	770	Winter	Spawned
3/20/2007	80079	Y-295	Absent	Female	800	Winter	Released@Posse
3/20/2007	80080	Y-297	Absent	Female	690	Winter	Released@Posse
3/20/2007	80081	Y-299	Absent	Male	740	Winter	Released@Posse
3/20/2007	80082	Y-301	Absent	Male	770	Winter	Released@Posse
3/20/2007	80083	Y-303	Present	Male	1000	Non-Winter	Released@Posse
3/20/2007	80084	Y-305	Absent	Male	750	Winter	Released@Posse
3/20/2007	80085	Y-307	Absent	Female	780	Winter	Released@Posse
3/20/2007		Y-285	Absent	Female	790	undetermined	Released@Posse
3/27/2007	80086	Y-312	Present	Female	740	Winter	Spawned
3/27/2007	80087	Y-317	Present	Female	790	Winter	Spawned
3/27/2007	80088	Y-322	Present	Female	710	Winter	Spawned
3/27/2007	80089	Y-327	Absent	Female	950	Non-Winter	Sacrificed

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
3/27/2007	80090	Y-330	Present	Male	830	Winter	Spawned
3/27/2007	80091	Y-331	Absent	Male	1015	Non-Winter	Sacrificed
3/27/2007	80092	Y-332	Present	Male	720	Winter	Spawned
3/27/2007	80093	Y-333	Present	Female	790	Winter	Spawned
3/27/2007	80094	Y-336	Present	Male	840	Winter	Spawned
3/27/2007	80095	Y-339	Present	Male	880	Winter	Prespawn
3/27/2007	80096	Y-340	Present	Female	850	Winter	Spawned
3/27/2007	80097	Y-341	Present	Male	820	Winter	Spawned
3/27/2007	80098	Y-348	Present	Female	800	Winter	Released@Posse
3/27/2007	80099	Y-349	Present	Female	775	Winter	Spawned
3/27/2007	80100	Y-350	Absent	Male	780	Winter	Released@Posse
3/27/2007	80101	Y-375	Present	Male	860	Winter	Spawned
3/27/2007	80102	Y-378	Present	Male	830	Winter	Spawned
3/27/2007	80103	Y-313	Absent	Female	820	Winter	Released@Posse
3/27/2007	80104	Y-315	Absent	Male	900	Winter	Released@Posse
3/27/2007	80105	Y-318	Present	Female	950	Non-Winter	Released@Posse
3/27/2007	80106	Y-320	Absent	Female	750	Winter	Released@Posse
3/27/2007	80107	Y-323	Absent	Male	850	Winter	Released@Posse
3/27/2007	80108	Y-325	Absent	Male	870	Winter	Released@Posse
3/27/2007	80109	Y-328	Absent	Male	760	Winter	Released@Posse
3/27/2007	80110	Y-334	Present	Female	780	Winter	Released@Posse
3/27/2007	80111	Y-337	Absent	Male	720	Winter	Released@Caldwell
3/27/2007	80112	Y-342	Present	Female	800	Non-Winter	Released@Posse
3/27/2007	80113	Y-344	Absent	Female	770	Winter	Released@Posse
3/27/2007	80114	Y-346	Absent	Male	930	Winter	Released@Posse
3/27/2007	80115	Y-351	Absent	Male	860	Winter	Released@Posse
3/27/2007	80116	Y-354	Absent	Female	880	Winter	Released@Posse
3/27/2007	80117	Y-356	Absent	Female	840	Winter	Released@Posse
3/27/2007	80118	Y-359	Absent	Female	740	Winter	Released@Posse
3/27/2007	80119	Y-361	Present	Male	1000	Winter	Released@Posse
3/27/2007	80120	Y-363	Present	Female	730	Winter	Released@Posse
3/27/2007	80121	Y-365	Present	Male	810	Winter	Released@Posse
3/27/2007	80122	Y-367	Absent	Female	690	Winter	Released@Posse
3/27/2007	80123	Y-369	Present	Male	830	Winter	Released@Posse
3/27/2007	80124	Y-371	Present	Male	810	Winter	Released@Posse
3/27/2007	80125	Y-373	Absent	Female	830	Winter	Released@Posse
3/27/2007	80126	Y-376	Present	Female	790	Winter	Released@Posse
4/3/2007	80127	Y-381	Present	Male	810	Winter	Released@Caldwell
4/3/2007	80128	Y-383	Present	Female	820	Non-Winter	Released@Caldwell
4/3/2007	80129	Y-385	Absent	Male	770	Winter	Released@Caldwell

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
4/3/2007	80130	Y-387	Present	Male	770	Winter	Spawned
4/3/2007	80131	Y-388	Absent	Male	890	Winter	Released@Caldwell
4/3/2007	80132	Y-390	Present	Male	820	Winter	Spawned
4/3/2007	80133	Y-391	Present	Female	710	Non-Winter	Released@Caldwell
4/10/2007	80134	Y-395	Present	Male	920	Winter	Spawned
4/10/2007	80135	Y-393	Absent	Male	900	Winter	Released@Caldwell
4/10/2007	80136	Y-396	Absent	Female	670	Non-Winter	Released@Caldwell
4/10/2007	80137	Y-399	Present	Male	920	Winter	Released@Caldwell
4/10/2007	80138	Y-403	Present	Male	950	Winter	Spawned
4/10/2007	80139	Y-404	Absent	Male	650	Winter	Released@Caldwell
4/10/2007	80140	Y-406	Present	Male	750	Winter	Released@Caldwell
4/10/2007	80141	Y-408	Absent	Male	770	Winter	Released@Caldwell
4/10/2007	80142	Y-410	Present	Male	1000	Winter	Spawned
4/10/2007	80143	Y-411	Absent	Female	840	Winter	Released@Caldwell
4/10/2007	80144	Y-413	Absent	Female	780	Winter	Released@Caldwell
4/10/2007	80145	Y-417	Absent	Female	790	Winter	Released@Caldwell
4/10/2007	80146	Y-418	Absent	Male	700	Winter	Released@Caldwell
4/10/2007	80147	Y-420	Present	Female	820	Winter	Prespawn
4/10/2007	80148	Y-421	Present	Male	860	Winter	Spawned
4/10/2007	80149	Y-422	Present	Male	860	Winter	Spawned
4/10/2007	80150	Y-423	Absent	Female	700	Winter	Released@Caldwell
4/10/2007	80151	Y-425	Present	Female	920	Winter	Spawned
4/10/2007	80152	Y-426	Absent	Female	0	Winter	Released@Caldwell
4/10/2007	80153	Y-428	Absent	Female	875	Winter	DIP
4/10/2007	80154	Y-430	Absent	Female	810	Winter	Released@Caldwell
4/10/2007	80155	Y-432	Absent	Female	780	Winter	Released@Caldwell
4/10/2007	80156	Y-434	Absent	Female	730	Winter	Released@Caldwell
4/10/2007	80157	Y-436	Absent	Male	810	Winter	DIP
4/10/2007		Y-401	Absent	Female	760	undetermined	Released@Caldwell
4/17/2007	80158	Y-437	Present	Female	800	Non-Winter	Released@Caldwell
4/17/2007	80159	Y-439	Present	Male	690	Winter	Spawned
4/17/2007	80160	Y-440	Absent	Male	850	Winter	Released@Caldwell
4/17/2007	80161	Y-442	Absent	Female	780	Winter	Released@Caldwell
4/17/2007	80162	Y-443	Present	Male	900	Winter	Released@Caldwell
4/17/2007	80163	Y-445	Absent	Female	730	Winter	Released@Caldwell
4/17/2007	80164	Y-447	Present	Male	805	Winter	Prespawn
4/17/2007	80165	Y-448	Absent	Male	1000	Winter	Released@Caldwell
4/17/2007	80166	Y-450	Present	Female	760	Non-Winter	Released@Caldwell
4/17/2007	80167	Y-452	Present	Female	770	Winter	Released@Caldwell
4/17/2007	80168	Y-454	Absent	Male	740	Winter	Released@Caldwell

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
4/17/2007	80169	Y-456	Present	Male	460	Non-Winter	Released@Caldwell
4/24/2007	80170	Y-463	Absent	Male	960	No Call	DIP
4/24/2007	80171	Y-464	Absent	Female	810	Winter	Released@Caldwell
4/24/2007	80172	Y-466	Present	Male	890	Winter	Released@Caldwell
5/1/2007	80173	Y-468	Present	Female	780	Winter	Spawned
5/15/2007	80174	Y-469	Absent	Female	820	Winter	Released@Caldwell
5/15/2007	80175	Y-471	Absent	Female	950	Winter	Released@Caldwell
5/15/2007	80176	Y-473	Present	Male	520	Non-Winter	Released@Caldwell
5/15/2007	80177	Y-475	Present	Male	430	Winter	Released@Caldwell
5/22/2007	80180	Y-481	Absent	Female	770	Winter	Released@Caldwell
5/29/2007	80181	Y-483	Present	Male	900	Winter	Released@Caldwell
5/29/2007	80182	Y-485	Present	Male	500	Non-Winter	Released@Caldwell
5/29/2007	80183	Y-487	Present	Female	770	Non-Winter	Released@Caldwell
6/5/2007	80187	Y-492	Present	Male	800	Winter	Released@Caldwell
6/5/2007	80188	Y-495	Present	Female	730	Non-Winter	Released@Caldwell
6/5/2007	80189	Y-497	Present	Male	465	Non-Winter	Released@Caldwell
6/5/2007	80190	Y-499	Present	Male	880	Winter	Released@Caldwell
6/5/2007	80191	OR-001	Present	Male	520	Non-Winter	Released@Caldwell
6/5/2007	80192	OR-003	Absent	Female	760	Winter	Released@Caldwell
6/5/2007	80193	OR-005	Present	Female	840	Non-Winter	Released@Caldwell
6/11/2007	80194	OR-010	Present	Female	770	Winter	Spawned
6/11/2007	80195	OR-011	Present	Female	720	Non-Winter	Released@Caldwell
6/11/2007	80196	OR-013	Absent	Female	865	Winter	Spawned
6/19/2007	80197	OR-015	Present	Male	820	Winter	Spawned
6/19/2007	80198	OR-016	Absent	Female	794	Winter	Spawned
6/19/2007	80199	OR-017	Present	Male	950	Winter	Spawned
6/19/2007	80200	OR-018	Present	Male	890	Winter	Spawned
6/19/2007	80201	OR-019	Absent	Female	778	Winter	Spawned
6/19/2007	80202	OR-020	Present	Male	770	Non-Winter	Released@Caldwell
6/26/2007	80203	OR-023	Absent	Female	680	Winter	Spawned
7/2/2007	80204	OR-026	Absent	Female	735	Winter	Released@Caldwell
7/2/2007	80205	OR-028	Present	Male	900	Winter	Released@Caldwell
7/2/2007	80206	OR-030	Absent	Female	800	Winter	Released@Caldwell
7/2/2007	80207	OR-032	Absent	Male	910	Winter	Released@Caldwell
7/10/2007	80208	OR-034	Absent	Female	760	Winter	Released@Caldwell
7/10/2007	80209	OR-037	Absent	Female	720	Winter	Released@Caldwell
7/17/2007	80210	OR-051	Present	Female	800	Winter	Spawned
7/17/2007	80211	OR-052	Absent	Female	760	Winter	Released@Caldwell
7/17/2007	80212	OR-054	Absent	Female	710	Winter	Spawned
7/17/2007	80213	OR-056	Absent	Female	730	Winter	Released@Caldwell

Table 5. (continued)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Gender	FL (mm)	Run Assignment	Final Dispositiona
7/17/2007	80214	OR-060	Absent	Male	190	Winter	Sacrificed
7/17/2007	80215	OR-061	Present	Female	780	Winter	Spawned
7/24/2007	80216	OR-062	Present	Male	800	Winter	Spawned
7/24/2007	80217	OR-063	Present	Male	530	Winter	Spawned
7/24/2007	80218	OR-064	Present	Female	707	Non-Winter	Released@Caldwell
7/24/2007	80219	OR-066	Absent	Female	830	Non-Winter	Sacrificed
7/24/2007	80220	OR-067	Present	Male	530	Non-Winter	Released@Caldwell
7/24/2007	80221	OR-058	Absent	Unknown	0	undetermined	Unknown

a DIT = fish that died in the Keswick trap; Prespawn = fish that died in the hatchery holding pond; Released@Caldwell = released at Caldwell Park, ~river mile 298.5; Released@Posse = released at Posse Grounds, ~river mile 298; Sacrificed = hatchery Chinook euthanized for coded wire tag analysis; Spawned = 2007 winter Chinook brood stock; TransferredCNFH = non-winter transferred to Coleman National Fish Hatchery for additional late-fall brood stock.

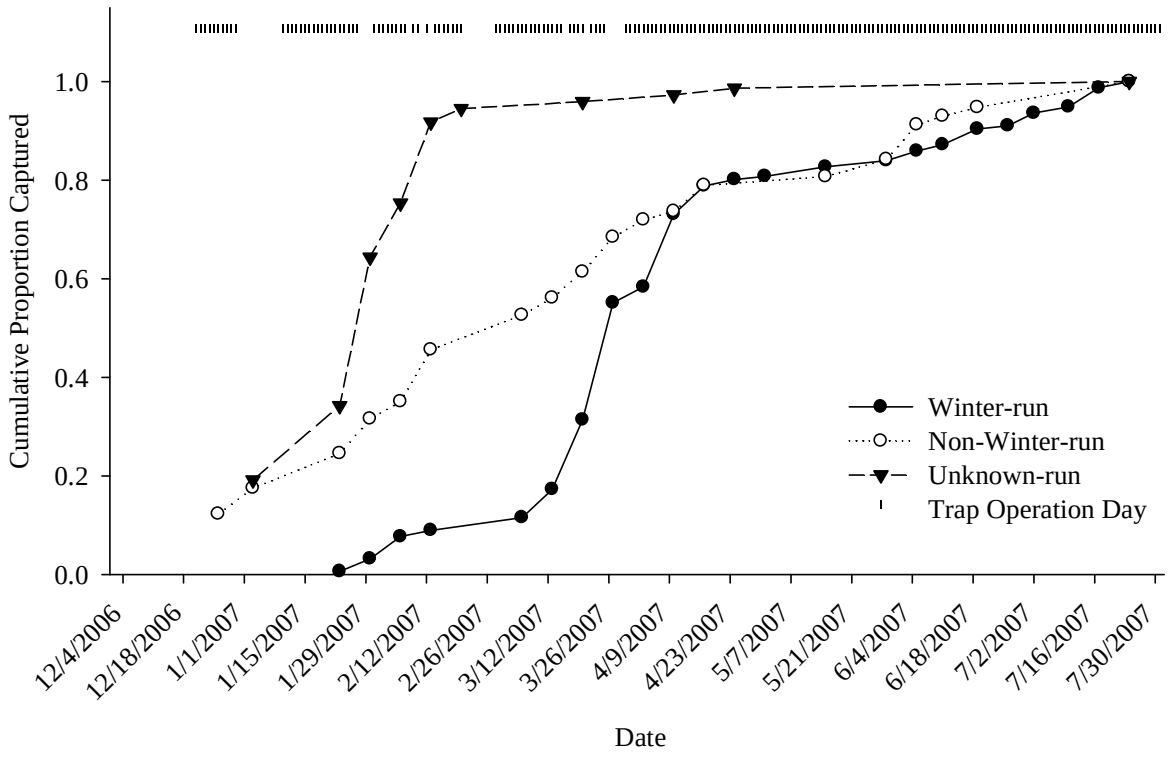

Figure 1. Capture timing of Chinook salmon from the Keswick Dam trap by run-type, brood year 2007.

Table 6. Disposition of Chinook salmon trapped at Keswick Dam trap from February 19, 2008 – July 22, 2008; grouped by run identity and gender. Numbers in parentheses indicate the number of hatchery-origin fish included in the category total.

Run Identity	Disposition	Total	Males	Females	Unknown
Winter	Trapped and spawned	44 (5)	25 (0)	19 (5)	0 (0)
Winter	Pre-spawn mortality	9 (3)	6 (2)	3 (1)	0 (0)
Winter	Trapped, quarantined, and released back into river	4 (2)	1 (1)	3 (1)	0 (0)
Winter	Trapped and released back into river without quarantine	99 (75)	47 (32)	50 (41)	2 (2)
Winter	Euthanized	1 (1)	1 (1)	0 (0)	0 (0)
	Subtotal	157 (86)	80 (36)	75 (48)	2 (2)
Non-winter	Pre-spawn mortality	1 (1)	1 (1)	0 (0)	0 (0)
Non-winter	Trapped, quarantined, and released back into river	1 (0)	1 (0)	0 (0)	0 (0)
Non-winter	Trapped and released back into river without quarantine	36 (1)	14 (0)	22 (1)	0 (0)
Non-winter	Transferred to Coleman National Fish Hatchery	70 (0)	32 (0)	38 (0)	0 (0)
Non-winter	Euthanized	15 (15)	8 (8)	7 (7)	0 (0)
	Subtotal	123 (17)	56 (9)	67 (8)	0 (0)
Undetermined	Pre-spawn mortality	1 (0)	0 (0)	1 (0)	0 (0)
Undetermined	Trapped, quarantined, and released back into river	0 (0)	0 (0)	0 (0)	0 (0)
Undetermined	Trapped and released back into river without quarantine	4 (4)	1 (1)	3 (3)	0 (0)
	Subtotal	5 (4)	1 (1)	4 (3)	0 (0)
	Total	285 (107)	137 (46)	146 (59)	2 (2)

Health

Sacramento River brood stock tested positive for infectious hematopoietic necrosis virus (Table 7). No other causative agent was present in brood stock from the Sacramento River and Livingston Stone NFH.

Table 7. Test results (positive or negative) for fish pathogens in brood year 2007 winter Chinook salmon brood stock and juveniles, conducted by the U. S. Fish & Wildlife Service's California - Nevada Fish Health Center.

Pathogen	Adult	Juveniles[a]
Aeromonas salmonicida	negative	negative
Yersinia ruckeri	negative	negative
Renibacterium salmoninarum	negative	positive
Myxobolus cerebralis	no test	no test
Infectious hematopoietic necrosis virus	positive	negative
Viral hemorrhagic septicemia virus	negative	negative
Infectious pancreatic necrosis virus	negative	negative
Oncorynchus masou virus	negative	no test
Ceratomyxa shasta	negative	negative
Parvicapsula minibicornis	negative	no test

[a] Juvenile progeny of the brood stock origin types were combined for the assay.

Spawning & Production

Brood year 2007 winter Chinook salmon were spawned between May 29, 2007 and July 26, 2007 (Tables 2 and 3, Figure 2). A total of 24 female (Table 2) and 20 male (Table 3) winter Chinook salmon were spawned producing 48 family groups (Table 8). Fork length of spawned females ranged from 680 to 920 mm and averaged 775 mm (Table 2). Fork length of spawned males ranged from 530 to 1,000 mm and averaged 836 mm (Table 3). Females produced an average of 5,056 green eggs yielding a total of 121,341 green eggs, with 92% of these developing into eyed eggs (Table 8). The percent of green eggs that hatched averaged 90%, and 83% of the green eggs resulted in juveniles that were transferred to rearing tanks (Table 8).

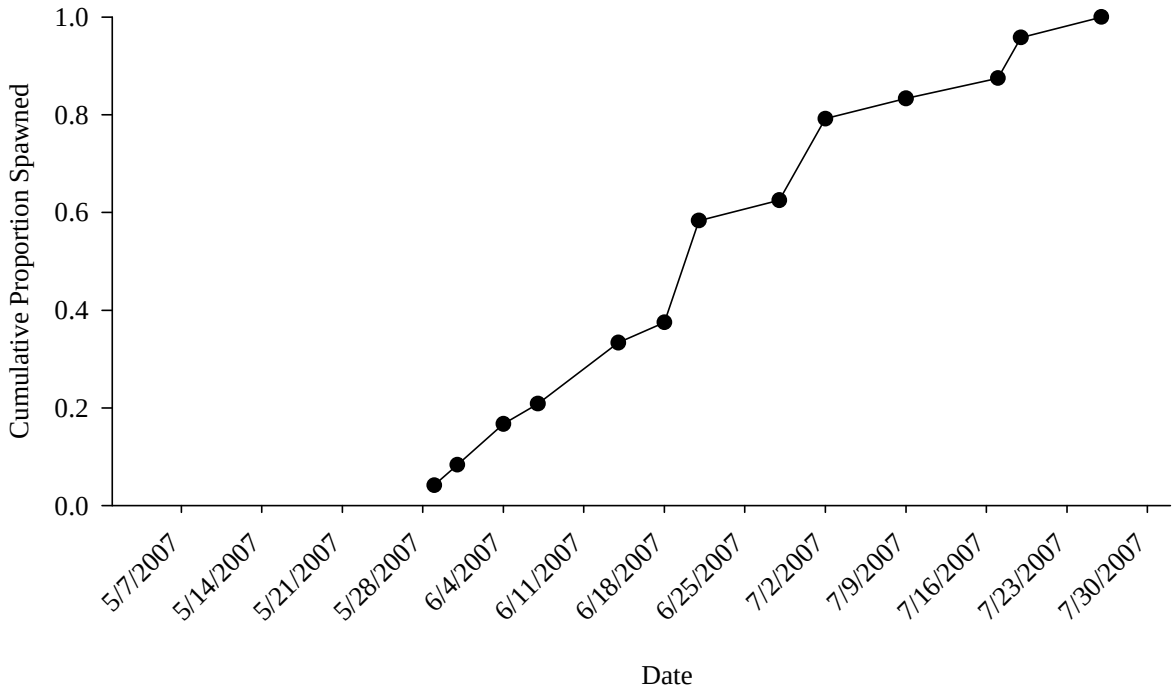

Figure 2. Spawn timing of winter Chinook salmon at Livingston Stone National Fish Hatchery, brood year 2007.

Table 8. Early survival[a] of eggs and fry from winter Chinook salmon captured from the wild and spawned at Livingston Stone National Fish Hatchery, 2007.

Crosses by floy tag		Family	Date	Green	Eyed	Percent	Number	Percent Green	Number	Percent Green	Percent Eyed
Female	Male	Group	Spawned	Eggs	Eggs	Eyed	Hatched	Eggs Hatched	Tanked	Eggs Tanked	Eggs Tanked
Y-333	Y-403	1A	5/29/2007	2,937	2,820	96	2,792	95	2,442	83	87
Y-333	Y-223	1B	5/29/2007	3,082	2,435	79	2,415	78	1,490	48	61
Y-340	Y-403	2A	5/31/2007	3,037	2,851	94	2,820	93	2,695	89	95
Y-340	Y-223	2B	5/31/2007	2,542	2,388	94	2,356	93	2,316	91	97
Y-253	Y-412	3C	6/4/2007	3,028	2,881	95	2,853	94	2,440	81	85
Y-253	Y-410	3D	6/4/2007	2,215	2,138	97	2,117	96	2,101	95	98
Y-284	Y-412	4C	6/4/2007	3,222	3,134	97	3,107	96	2,555	79	82
Y-284	Y-278	4E	6/4/2007	3,112	3,020	97	2,994	96	2,940	94	97
Y-425	Y-278	5E	6/7/2007	3,363	3,198	95	3,181	95	1,247	37	39
Y-425	Y-378	5F	6/7/2007	3,151	3,094	98	3,082	98	1,520	48	49
Y-439	Y-375	6G	6/14/2007	2,265	2,176	96	2,118	94	1,922	85	88
Y-439	Y-422	6H	6/14/2007	2,220	1,656	75	1,634	74	1,472	66	89
Y-349	Y-410	7D	6/14/2007	2,741	2,584	94	2,412	88	1,773	65	69
Y-349	Y-336	7I	6/14/2007	2,682	2,512	94	2,318	86	2,229	83	89
Y-283	Y-410	8D	6/14/2007	3,254	3,229	99	3,197	98	3,197	98	99
Y-283	Y-278	8E	6/14/2007	2,858	2,768	97	2,726	95	2,721	95	98
Y-294	Y-422	9H	6/18/2007	2,322	1,593	69	1,580	68	1,561	67	98
Y-294	Y-336	9I	6/18/2007	2,209	2,175	98	2,162	98	2,143	97	99
Y-273	Y-422	10J	6/21/2007	1,945	1,924	99	1,914	98	1,892	97	98
Y-273	Y-341	10K	6/21/2007	1,768	1,732	98	1,719	97	1,694	96	98
OR-013	OR-017	11G	6/21/2007	1,907	0	0	0	0	0	0	0
OR-013	Y-375	11L	6/21/2007	1,869	0	0	0	0	0	0	0
OR-010	OR-017	12G	6/21/2007	2,677	2,618	98	2,598	97	2,568	96	98
OR-010	Y-375	12L	6/21/2007	2,387	2,270	95	2,217	93	2,185	92	96
OR-019	OR-018	13M	6/21/2007	2,781	2,746	99	2,738	98	2,615	94	95
OR-019	OR-015	13N	6/21/2007	2,532	2,525	100	2,503	99	2,480	98	98
OR-016	OR-018	14M	6/21/2007	2,869	2,864	100	2,859	100	2,859	100	100
OR-016	OR-015	14N	6/21/2007	2,340	2,326	99	2,319	99	2,293	98	99
Y-272	Y-422	15J	6/28/2007	2,551	2,538	99	2,520	99	2,493	98	98

Table 8. (continued)

Crosses by floy tag		Family	Date	Green	Eyed	Percent	Number	Percent Green	Number	Percent Green	Percent Eyed
Female	Male	Group	Spawned	Eggs	Eggs	Eyed	Hatched	Eggs Hatched	Tanked	Eggs Tanked	Eggs Tanked
Y-272	Y-341	15K	6/28/2007	1,742	1,729	99	1,706	98	1,696	97	98
Y-312	Y-422	16H	7/2/2007	2,701	2,678	99	2,661	99	2,651	98	99
Y-312	Y-341	16K	7/2/2007	2,679	2,666	100	2,657	99	2,627	98	99
Y-468	Y-336	17I	7/2/2007	3,251	3,241	100	3,219	99	3,182	98	98
Y-468	Y-422	17J	7/2/2007	3,142	3,136	100	3,121	99	3,088	98	98
Y-317	Y-387	18P	7/2/2007	2,327	2,241	96	2,136	92	2,126	91	95
Y-317	Y-390	18R	7/2/2007	2,764	2,698	98	2,605	94	2,583	93	96
OR-023	Y-332	19O	7/2/2007	1,902	1,886	99	1,858	98	1,835	96	97
OR-023	Y-387	19P	7/2/2007	2,249	2,236	99	2,182	97	2,146	95	96
Y-322	Y-330	20Q	7/9/2007	2,515	2,358	94	2,355	94	2,269	90	96
Y-322	Y-390	20R	7/9/2007	2,187	1,956	89	1,928	88	1,897	87	97
OR-061	Y-332	21O	7/17/2007	2,048	1,596	78	1,467	72	1,316	64	82
OR-061	Y-387	21P	7/17/2007	2,555	2,000	78	1,908	75	1,893	74	95
Y-291	Y-332	22O	7/19/2007	1,750	1,656	95	1,464	84	1,230	70	74
Y-291	Y-330	22Q	7/19/2007	1,420	1,298	91	1,016	72	876	62	67
OR-051	Y-332	23O	7/19/2007	2,753	2,712	99	2,696	98	2,630	96	97
OR-051	Y-330	23Q	7/19/2007	2,984	2,940	99	2,906	97	2,682	90	91
OR-054	OR-063	24S	7/26/2007	2,069	2,057	99	2,046	99	1,975	95	96
OR-054	OR-062	24T	7/26/2007	2,437	2,407	99	2,407	99	2,364	97	98
			Total	121,341	111,686		109,589		100,909		
			Average[a]	5,056	4,856	92	4,765	90	4,387	83	90

[a] Averages derived from the number of females spawned (n = 24), not the number of family groups. All females considered for average green eggs per female, however; average eyed eggs, number hatched, and number tanked per female does not include female 11 (did not contribute to these categories).

Progeny

Rearing

Between the dates of initial feeding (August 10, 2007) and release (January 31, 2008), progeny were fed a total of 1,100 pounds of fish feed, resulting in a total weight gain by the fish of 1,103 pounds (food conversion rate of 1.00). The average length increase of the fish from time of initial feeding to release was 57 mm.

Marking and Tagging

Coded-wire tagging of juvenile winter Chinook occurred between December 27, 2007 and January 9, 2008. At the time of tagging, adipose fins were removed from all fish so they could easily be identified as hatchery-origin fish upon return. Juveniles tagged and marked included: 56,330 natural-origin × natural-origin progeny and 15,615 natural-origin × hatchery-origin progeny (Table 4). The marking and tagging mortality rate for all groups combined was less than 0.1%.

Health

Juvenile progeny were tested for seven different pathogens. The only positive test result was for *Renibacterium salmoninarum* (Table 7). Much of the early life stage mortality that occurred in brood year 2006 progeny was attributed to a combination of coagulated yolk (in incubators and early rearing stages) and bacterial gill disease (early rearing stage). It was later theorized that fine silt within the supply water may have damaged the juvenile gill membranes leading to the high mortality. In 2007, mortalities in the incubator trays were reduced by the addition of a 100 ug mesh screen to remove the fine silt from the supply water.

Released

A total of 71,883 juvenile winter Chinook were released at Caldwell Park (river mile 298) on January 31, 2008. Accounting for mortality after tagging and tag retention, an estimated 69,120 marked and tagged winter Chinook were released (Table 4). Most (78%) of the fish released were from natural-origin × natural-origin crosses and the rest (22%) were from natural-origin × hatchery-origin crosses.

Assessment of Potential Genetic Impacts

When brood year 2007 hatchery propagation data was applied to the population genetics model (Hedrick et al. 1995), the model indicated loss of genetic variation due to genetic drift was not likely to occur (Attachment A). Under the scenario that 10% of the naturally-spawning population was successful at producing progeny, the hatchery program increased the effective population size from 254 to 264 spawners. Under the scenario that 33% of the population was

successful at producing progeny, the hatchery program increased the effective population size from 846 to 872 individuals.

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ACKNOWLEDGEMENTS

Data for this report was collected by John Rueth, manager of Livingston Stone National Fish Hatchery, and Beau Hopkins fish culturist at Livingston Stone National Fish Hatchery. Scott Hamelberg is the project leader of Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery operations. Kevin Offill prepared the report.

Attachment A-- Brood Year 2007 Effective Population Size Methodology, Estimates, and Assumptions

Effective Population Size Calculation

The effective population size (N_e) is a measure of the rate of genetic drift within a population. The N_e is directly related to the rate of loss of genetic diversity and the rate of increase in inbreeding within a population (Rieman and Allendorf 2001), and is an important concept in managing conservation programs for threatened or endangered salmonid populations, including Sacramento River winter Chinook. In most cases N_e is expected to be smaller than the actual number of adults in a spawning population. We used a tripartite model to estimate the effective population size. This model incorporates the joint effects of finite population size of wild, hatchery-reared, and captive brood stock individuals on the overall effective population size (Hedgecock et al 2002).

Our approximation of N_e for winter Chinook salmon is based on the estimated total run size to the Upper Sacramento River. Since 2001, the winter Chinook run size estimate has been derived from carcass survey data using the Jolly-Seber formula (Height 2002). Beginning in 2003 estimates were made using only the adult female data from this survey and expanding the adult female estimate using the male-to-female ratio for winter Chinook salmon observed at the Keswick Dam fish trap (Manji 2007). Prior to 2001, run size estimates were derived from Red Bluff Diversion Dam (RBDD) counts. Two estimates of natural-origin winter Chinook N_e were generated: one using 10% of the run size estimate and one using 33% of the run size estimate. Each value is an estimate of the proportion of the total spawning population that contributed to the effective population of natural spawners. The lower value ($0.10N_s$) was estimated by Bartley et al. (1992), while the upper value was estimated from an analysis of Snake River, Idaho data (Robin Waples, NMFS, Northwest Fisheries Center, Seattle, WA, personal communication). The effective population sizes bounded by these two values is consistent with that presented by Hedrick et al. (1995, 2000, and 2000_b) and decisions reached at the February 27, 1998 meeting of the winter Chinook salmon captive brood stock genetics subcommittee.

The brood year 2007 release group, consisting of 71,883 juveniles, was the progeny of 24 females and 20 male. A final release number for each mating was derived by apportioning mortality between all family groups within a rearing unit. For example, when two family groups were combined into a single rearing unit mortality was allocated proportionally, relative to the number of salmon from each family group. This method assumes equal rates of survival for all family groups combined in a common rearing unit.

The hatchery component of the effective population is an estimated 71 (Tables A1 and A2). The model indicates the overall effective population size would increase from 254 to 264 ($N_{ew} = 0.10 \times N_s$) or 846 to 872 ($N_{ew} = 0.33 \times N_s$) as a result of the hatchery supplementation program (Tables A1 and A2). This suggests the effect of the brood year 2007 release on the winter Chinook salmon population will be negligible from genetic drift. Model assumptions for these calculations are presented in Appendix I.

Table A1. Estimated genetic impact of the release of brood year 2007 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the effective population size (N_e). The calculation assumes N_e(wild) = 0.10 multiplied by the estimated run size.

2007 Run Size 2,541[1]

	Captured Adults	Natural Spawners
Available Adults	53[2]	2,488
Pre-Spawn Mortality Rate	0.17	0.02
Est. Effective Population Size	71	249
Number of Females	23	1,542
Eggs per Female	5,112[3]	5,112[3]
Total Eggs	117,575	7,882,704
Survival to Fry		1,970,676
Survival to Pre-Smolt, Release	71,883	
Survival to Smolt, Post-Release	35,942	1,162,699
Total Smolt Production		1,198,640
Percentage of Production	3.0%	97.0%

Effective Population Size	264	(WITH HATCHERY INFLUENCE)
	254	(WITHOUT HATCHERY INFLUENCE)

[1] Year 2007 run-size estimate of winter Chinook salmon generated by the California Department of Fish and Game. Since 2001, the Jolly-Seber formula has been used to estimate run-size and, beginning in 2003, only the adult female data from the carcass survey was used in this formula and the total population estimate was derived by expanding the adult female estimate using the male-to-female ratio for winter Chinook salmon observed at the Keswick Dam fish trap. This value includes the estimates of returning winter Chinook salmon transferred and retained at the Livingston Stone NFH.

[2] Does not include hatchery-origin precocious male (fork length = 190 mm) that was sacrificed to obtain coded-wire tag data.

[3] Number of eggs per female was calculated based on data collected at Livingston Stone NFH.

Table A2. Estimated genetic impact of the release of brood year 2007 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the effective population size (N_e). The calculation assumes N_e(wild) = 0.333 multiplied by the estimated run size.

2007 Run Size 2,541[1]

	Captured Adults	Natural Spawners
Available Adults	53[2]	2,488
Pre-Spawn Mortality Rate	0.17	0.02
Est. Effective Population Size	71	829
Number of Females	23	1,542
Eggs per Female	5,112[3]	5,112[3]
Total Eggs	117,575	7,882,704
Survival to Fry		1,970,676
Survival to Pre-Smolt, Release	71,883	
Survival to Smolt, Post-Release	35,942	1,162,699
Total Smolt Production		1,198,640
Percentage of Production	3.0%	97.0%

Effective Population Size	872	(WITH HATCHERY INFLUENCE)
	846	(WITHOUT HATCHERY INFLUENCE)

1 Year 2007 run-size estimate of winter Chinook salmon generated by the California Department of Fish and Game. Since 2001, the Jolly-Seber formula has been used to estimate run-size and, beginning in 2003, only the adult female data from the carcass survey was used in this formula and the total population estimate was derived by expanding the adult female estimate using the male-to-female ratio for winter Chinook salmon observed at the Keswick Dam fish trap. This value includes the estimates of returning winter Chinook salmon transferred and retained at the Livingston Stone NFH.

2 Does not include hatchery-origin precocious male (fork length = 190 mm) that was sacrificed to obtain coded-wire tag data.

3 Number of eggs per female was calculated based on data collected at Livingston Stone NFH.

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Appendix I

Assumptions for the population genetics model used to determine effective population size with and without hatchery influence.

Assumptions for the population genetics model are based on the following best available information:

- Estimated run size for 2007 (2,541) was based on data collected in the Upper Sacramento River Winter-run Escapement Survey (Manji, 2007).

- Two estimates of the effective population size were generated: one using 10% of the run size estimate and one using 33% of the run size estimate. The lower value ($0.10N_s$) was estimated by Bartley et al. (1992), while the upper value was estimated from Snake River data (Robin Waples, NMFS, Northwest Fisheries Center, Seattle, WA, personal communication). Presentation of the effective population sizes bounded by these two values is consistent with that presented by Hedrick et al. (1995) and decisions reached at the February 27, 1998 meeting of the winter Chinook salmon captive brood stock genetics subcommittee. This value takes into consideration factors reducing N_{ew} such as unequal sex ratios, differential fecundity rates, and the inability of some individuals to spawn.

- Number of females spawning naturally in the upper Sacramento River (1,542) was based on data collected in the Upper Sacramento River Winter-run Escapement Survey (Manji, 2007).

- The proportion of male and females was assumed to be 0.4 and 0.6, respectively, was based on data collected in the Upper Sacramento River Winter-run Escapement Survey (Doug Killam, CDFG, personal communication)

- Number of eggs per female is consistent with measures of fecundity noted at the Livingston Stone National Fish Hatchery in 2007.

- 25% survival from egg to fry stage for the wild population.

- 59% survival from fry to smolt stage for the wild population (Hallock, undated[1]).

  Assumptions for hatchery production which differ from wild production include:

- 50% survival from pre-smolt to smolt stage for the hatchery population.

- Effective population sizes for the hatchery (N_{eh}) and captive brood stock (N_{eb}) portions of the run are calculated using:

[1] Hallock, R.J. Undated. The Status of Inland Habitat and Factors Adversely Impacting Salmon Resources.

Appendix I (continued)

$$N_{ec} = \frac{4N_f N_m}{xN_f + yN_m}$$

where

$$x = f + m\frac{\sigma^2_{km}}{k_m}$$

and

$$y = m + f\frac{\sigma^2_{kf}}{k_f}$$

where N_f and N_m are the actual numbers of breeding females and males in the hatchery program, k_f and σ^2_{kf} are the mean and variance of the number of progeny produced by females and k_m and σ^2_{km} are the mean and variance of progeny numbers for the males, and m and f are the proportion of male (m) to female (f) spawners, where $m + f = 1$. We estimated the proportion of male and female spawners expected in subsequent years using the male and female proportions seen in this year's spawner carcass survey, m=0.38, f=0.62. The estimates used this year are similar to estimates used in the past from Hedrick et al. 2000 (m=0.4, f=0.6).

Information from wild and hatchery production is then incorporated into the following formula to calculate N_e:

$$N_e = \frac{N_{ew} N_{ec}}{x_w^2 N_{ec} + x_c^2 N_{ew}}$$

where N_{ec} and N_{ew} are the effective population sizes in the captive (hatchery) adults and the wild-run adults, respectively, and x_c and x_w are the proportions of progeny coming from the captive and wild adults, respectively ($x_c + x_w = 1$).

Appendix I (continued)

Further assumptions for this formula include:

(1) N_{ec} and N_{ew} are known;

(2) x_c and x_w, the proportions of spawners from wild and hatchery production are known;

(3) if (2) is not known, the hatchery and wild fish have equal survival to spawning and the initial proportion from each source is known;

(4) hatchery and wild fish mate at random; and,

(5) hatchery and wild females have equal egg numbers and survival of the next generation is the same in both groups.